Tex-207, Determining Density of Compacted Bituminous Mixtures

Section 1

Overview

Effective date: January 2005 — April 2007 (refer to 'Archived Versions' for earlier versions).

Use this test method to determine the bulk specific gravity of compacted bituminous mixture specimens. Use the bulk specific gravity of the specimens to calculate the degree of densification or percent compaction of the bituminous mixture.

Use Part I for all compacted bituminous mixtures except those with open or interconnecting voids and/or those that absorb more than 2.0% water by volume as determined by this procedure.

Use Part II for absorptive mixtures that have more than 2.0% water absorption.

Use Part III to determine the in-place density of compacted bituminous mixtures using a nuclear density gauge.

Use Part IV to establish roller patterns for a bituminous pavement.

Use Part V to identify segregation in bituminous asphalt pavement after placement on the roadway.

Use Part VI to determine the bulk specific gravity of compacted bituminous mixtures using the vacuum method.

Use Part VII to perform a longitudinal joint density evaluation of a bituminous asphalt pavement.

Refer to the following table when using Superpave specifications instead of standard department specifications. Replace department nomenclature with the Superpave nomenclature when required.

Nomenclature Key	
Department	**Superpave**
G_a = bulk specific gravity of the mixture	G_{mb}
G_p = specific gravity of the paraffin	G_p
G_t = calculated theoretical maximum specific gravity of the mixture at the specified asphalt content	$G_{max\text{-}theo}$
A_s = percent by weight of asphalt binder in the mixture	P_b
A_g = percent by weight of aggregate in the mixture	P_s
G_e = effective specific gravity of the combined aggregates	G_{se}
G_s = specific gravity of the asphalt binder determined at 77°F (25°C)	G_b
G_r = theoretical maximum specific gravity	G_{mm}
G_{rc} = theoretical maximum specific gravity corrected for water absorption during test	G_{mm}

Units of Measurement

The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

Definitions

This test method references the following terms:

- Bulk Specific Gravity - Bulk specific gravity is the ratio of the weight of the compacted bituminous mixture specimen to the bulk volume of the specimen.
- Percent Density or Percent Compaction - The percent density or percent compaction is the ratio of the actual bulk specific gravity of the compacted bituminous mixture specimen to the theoretical maximum specific gravity of the combined aggregate and asphalt contained in the specimen expressed as a percentage.

Section 2

Part I, Bulk Specific Gravity of Compacted Bituminous Mixtures

Use this procedure for all compacted bituminous mixtures except those with open or interconnecting voids and/or those that absorb more than 2.0% water by volume.

Apparatus

Use the following apparatus:

- balance, readable to 0.1 g and accurate to 0.5 g, equipped with suitable apparatus to permit weighing the specimen while suspended in water
- mercury thermometer marked in 0.5°C (1°F) divisions or digital thermometer capable of measuring the temperature specified in the test procedure
- water bath for immersing the specimen in water while suspended, equipped with an overflow outlet for maintaining a constant water level
- towel, suitable for surface drying the specimen.

Test Specimens

Test specimens may be laboratory-molded mixtures, pavement cores, or pavement slabs.

Avoid distorting, bending or cracking the specimens during and after removal from pavements or molds. Store the specimens in a cool place.

Assure the specimens are free of foreign materials such as seal coat, tack coat, soil, paper, or foil. Remove any of these materials when they are visually evident with a saw or by any other satisfactory means.

For roadway cores, the sample size and number of samples must conform to the requirements of "Tex-222-F, Sampling Bituminous Mixtures."

Procedures

- Specimens Containing Moisture

Follow these steps to determine the bulk specific gravity of the compacted bituminous mixture if the specimens contain moisture, such as roadway cores.

Bulk Specific Gravity of Specimens Containing Moisture

Step	Action
1	Determine the type of apparatus to use to weigh the samples suspended in water. Apparatus options: ♦ nonabsorptive string ♦ metal bucket or cage attached to the scale with a metal wire or a nonabsorptive string.

Bulk Specific Gravity of Specimens Containing Moisture

Step	Action
2	♦ Attach the apparatus to the scale and submerge in water. ♦ Tare the scale with the apparatus submerged in water.
3	Immerse the specimen in a water bath at 25 ±2°C (77 ±3°F).
4	Record the specimen weight and designate as ‘C’ under ‘Calculations’ when the scale readings stabilize.
5	♦ Remove specimen from water. ♦ Dry the surface by blotting quickly with a damp towel and then weigh in air. ♦ Record as the saturated surface dry weight (SSD), designated as ‘B’ under ‘Calculations.’
6	Oven-dry the specimen at a maximum temperature of 60 ±3°C (140 ±5°F) or air dry to constant weight. *NOTE*: Constant weight is defined as the weight at which further drying does not alter the weight by more than 0.05% in a 2-hr. interval.
7	Allow the specimen to cool then weigh in air.
8	Designate this weight as ‘A’ under ‘Calculations.’

♦ Thoroughly Dry Specimens

Follow these steps to determine bulk specific gravity if the specimens are thoroughly dry, such as laboratory molded specimens of HMAC.

Bulk Specific Gravity of Thoroughly Dry Specimens

Step	Action
1	Allow the specimen to cool and then weigh the dry specimen in air to the nearest 0.1 g. ♦ Allow the specimen to cool to room temperature and then weigh the dry specimen in air to the nearest 0.1 g. ♦ Record and designate this weight as ‘A’ under 'Calculations.'
2	Perform Steps 1 - 5 of the ‘Bulk Specific Gravity Specimens Containing Moisture’ procedure.

Calculations

Use the following calculations to determine bulk specific gravity and percent of water absorbed by the specimen:

$$G_a = \frac{A}{B - C}$$

Where:

- ♦ Ga = bulk specific gravity
- ♦ A = weight of dry specimen in air, g
- ♦ B = weight of the SSD specimen in air, g
- ♦ C = weight of the specimen in water, g.

$$Percent\ absorption = \frac{B - A}{B - C} \times 100$$

If the percent absorption exceeds 2%, then use the preferred method 'Part VI' of this test method. If the equipment is not available for this method, then use the alternative 'Part II' of this method.

Section 3

Part II, Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin

Use this procedure for absorptive mixtures, which have more than 2.0% water absorption.

Apparatus

Use the following apparatus:

- balance, readable to 0.1 g and accurate to 0.5 g, equipped with suitable apparatus to permit weighing of the specimen while suspended in water
- water bath, for immersing the specimen in water while suspended, equipped with an overflow outlet for maintaining a constant water level
- mercury thermometer marked in 0.5°C (1°F) divisions or digital thermometer capable of measuring the temperature specified in the test procedure
- sealed glass bulb, or similar object, weighted with lead shot (slightly heavier than an equal volume of water) so that it will submerge when placed in water. The bulb must have a volume of approximately 500 mL (15 oz.).

Test Specimens

Test specimens may be laboratory-molded mixtures, cores, or slabs obtained from bituminous pavements.

Avoid distorting, bending or cracking of the specimens during and after removal from pavements or molds. Store the specimens in a safe, cool place.

Assure that specimens are free of foreign materials such as seal coat, tack coat, soil, paper, or foil. Remove any of these materials when they are visually evident with a saw or by any other satisfactory means.

For roadway cores, the sample size and number of samples must conform to the requirements of "Tex-222-F, Sampling Bituminous Mixtures."

Materials

Use paraffin wax with an approximate melting point of 50°C (120°F)

Procedures

- ♦ Specific Gravity of Paraffin

Follow these steps to determine the specific gravity for the paraffin if it is unknown. The manufacturer may provide the specific gravity.

Determining Specific Gravity for Paraffin

Step	Action
1	♦ Weigh the sealed glass bulb in air. ♦ Record and designate this weight as 'D' under 'Calculations.'
2	Determine the type of apparatus to use to weigh the samples suspended in water. Apparatus options: ♦ nonabsorptive string ♦ metal bucket or cage attached to the scale with a metal wire or a nonabsorptive string.
3	♦ Attach the apparatus to the scale and submerge in water. ♦ Tare the scale with the apparatus submerged in water.
4	♦ Submerge the bulb in water at 25 ±2°C (77 ±3°F) and weigh to the nearest 0.1 g. ♦ Record and designate this weight as 'E' under 'Calculations.'
5	Heat approximately 2.5 kg (5 lb.) of paraffin in a 4 L (1 gal.) can until completely melted.
6	Allow the paraffin to cool after melting until a very thin film forms across the surface. NOTE: Lightly blow across the surface of the paraffin to determine if a very thin film forms. This film will form only at the spot where your breath touches the paraffin surface.
7	♦ Dip the sealed glass bulb into the prepared paraffin and withdraw immediately. ♦ Allow the paraffin on the bulb to cool and recoat the bulb with paraffin 2 more times.
8	♦ Weigh the paraffin-coated bulb, in air, to the nearest 0.1 g. ♦ Record and designate the weight as 'F' under 'Calculations.'
9	♦ Submerge the paraffin coated bulb in water at a temperature of 25 ±2°C (77 ±3°F) and weigh to the nearest 0.1 g. ♦ Record and designate the weight as 'G' under 'Calculations.'

- ♦ Compacted Bituminous Mixtures using Paraffin

Follow these steps to determine the bulk specific gravity of compacted bituminous mixtures using paraffin.

Determining Bulk Specific Gravity of Compacted Bituminous Mixtures using Paraffin

Step	Action
1	Perform Steps 1 - 9 in the 'Determining Specific Gravity for Paraffin' procedure if the specific gravity of the paraffin is unknown.
2	♦ Oven-dry the specimen at a maximum temperature of 60 ±3°C (140 ±5°F) to constant weight. ♦ Allow the specimen to cool and then weigh the dry specimen in air to the nearest 0.1 g. ♦ Record and designate this weight as 'A' under 'Calculations.' *NOTE*: Constant weight is defined as the weight at which further drying does not alter the weight by more than 0.05% in a 2-hr. interval.
3	♦ Prepare the melted paraffin as described in Steps 5 and 6 of the 'Determining Specific Gravity for Paraffin' procedure. ♦ Coat the specimen by dipping it into paraffin 3 times.

Determining Bulk Specific Gravity of Compacted Bituminous Mixtures using Paraffin	
Step	**Action**
	♦ Allow the paraffin coating to cool and solidify between each coating.
4	♦ Allow the specimen to cool and weigh the paraffin-coated specimen in air to the nearest 0.1 g. ♦ Record and designate this weight as 'B' under 'Calculations.'
5	Determine the type of apparatus to use to weigh the samples suspended in water. Apparatus options: ♦ nonabsorptive string ♦ metal bucket or cage attached to the scale with a metal wire or a nonabsorptive string.
6	♦ Attach the apparatus to the scale and submerge in water. ♦ Tare the scale with the apparatus submerged in water.
7	Completely submerge the suspended paraffin-coated specimen in water at 25 ±2°C (77 ±3°F).
8	♦ Weigh the paraffin-coated specimen in water. ♦ Record and designate this weight as 'C' under 'Calculations.' ♦ Immerse the specimen for a short time in hot tap water if it is necessary to remove the paraffin coating after determining the bulk specific gravity. ♦ Remove the cord and peel the paraffin off the specimen. *NOTE*: An option is to lightly dust the specimen with powdered talc before paraffin coating to facilitate paraffin removal.
9	Do not use the results calculated in this test procedure if this method yields a bulk specific gravity that is greater than the bulk specific gravity calculated in 'Part I' of this test method. *NOTE*: Use the results calculated in 'Part I' of this test method, when this occurs.

Calculations

Calculate the specific gravity of paraffin using the following formula:

$$G_p = \frac{(F - D)}{(F - G - D + E)}$$

Where:

- ♦ G_p = specific gravity of paraffin
- ♦ D = weight (grams) of bulb in air
- ♦ E = weight (grams) of bulb in water
- ♦ F = weight (grams) of paraffin coated bulb in air
- ♦ G = weight (grams) of paraffin coated bulb in water.

Calculate bulk specific gravity of the compacted specimen:

$$G_a = \frac{A}{B - C - \frac{(B - A)}{G_p}}$$

Where:

- ♦ G_a = bulk specific gravity of specimen
- ♦ A = weight (grams) of specimen in air
- ♦ B = weight (grams) of paraffin-coated specimen in air
- ♦ C = weight (grams) of paraffin-coated specimen in water
- ♦ G_p = specific gravity of paraffin.

Section 4

Part III, Determining In-Place Density of Compacted Bituminous Mixtures (Nuclear Method)

Use this procedure to determine the in-place density of compacted bituminous mixtures using a nuclear density gauge.

Apparatus

Use the following apparatus:

- nuclear density gauge
- portable reference standard
- calibration curves for the nuclear gauge
- scraper plate and drill rod guide
- drill rod and driver or hammer
- shovel, sieve, trowel, or straightedge and miscellaneous hand tools
- gauge logbook.

Standardization

Follow these steps to standardize the nuclear density gauge.

Standardizing the Nuclear Density Gauge

Step	Action
1	Turn on the apparatus and allow it to stabilize. *NOTE*: Follow the manufacturer's recommendations in order to ascertain the most stable and consistent results.
2	♦ Perform standardization with the apparatus located at least 25 ft. away from other sources of radioactivity. ♦ Clear the area of large masses or other items that may affect the reference count rate. *NOTE*: The preferred location for standardization checking is the pavement location tested. This is the best method for determining day to day variability in the equipment.
3	Take a minimum of 4 repetitive readings using the 'Reference Standard,' at the normal measurement period and determine the average of these readings. NOTE: One measurement period of 4 or more times the normal period is acceptable if available on the apparatus. This constitutes one standardization check.
4	♦ Detect the total number of gammas during the time period by determining the count per measurement period. ♦ Correct the displayed value for any prescaling built into the instrument. *NOTE*: The prescale value (F) is a divisor, which reduces the actual value for the purpose of display. The manufacturer will supply this value if other than 1.0. ♦ Record this corrected value as N_s.

Standardizing the Nuclear Density Gauge	
Step	**Action**
5	Use the value of N_s to determine the count ratios for the current day's use of the instrument. *NOTE*: Perform another standardization check if for any reason the measured density becomes suspect during the day's use.

The following table lists the required actions to take based on the results from Step 3 of the 'Standardizing Nuclear Testing Gauge' procedure.

Reference Standard	
If . . .	**Then. . .**
the value obtained is within the limits stated in limits calculation	the apparatus is considered to be in satisfactory operating condition and the value may be used to determine the count ratios for the day of use.
the value is outside these limits	allow additional time for the apparatus to stabilize, make sure the area is clear of sources of interference, then conduct another standardization check.
the second standardization check is within the limits	the apparatus may be used.
the second standardization check also fails the test	the apparatus must be adjusted or repaired as recommended by the manufacturer.

Calculations

Use these calculations in Step 3 of the 'Standardizing the Nuclear Density Gauge' procedure:

The limits are:

$$(N_s - N_o) \leq 2.0\sqrt{N_o / F}$$

Where:

- N_S = value of current standardization count
- N_o = average of the past 4 values of N_s taken previously
- F = value of any prescale.

Procedure

Follow these steps to determine the in-place density of compacted bituminous mixtures using a nuclear density gauge.

Determining In-Place Density of Compacted Bituminous Mixtures Using a Nuclear Density Gauge	
Step	**Action**
1	♦ Select an area that is relatively free of loose material, voids, or depressions. *NOTE*: Select an area at least 12 in. away from surface obstructions such as curbing, etc. ♦ It is optional to use fine sand to fill any voids or minor depressions. ♦ Avoid elevating the gauge above the surface of the material to be tested.
2	Measure the density of the selected area in either the backscatter or direct transmission mode. *NOTE*: The direct transmission method is only applicable for lifts greater than 2 in. thick.
3	Perform Steps 3 – 5 to measure the in-place density of compacted bituminous pavements using a nuclear density gauge in the backscatter mode.
4	Firmly seat the density gauge on the selected area so it is in full contact with the surface.
5	♦ Record the readings that are required at each location with the probe in the backscatter position. ♦ Do not leave the gauge in one position on the compacted bituminous pavement for a long time as erratic readings may result from the hot surface. ♦ Proceed to Step 11.
6	Perform Steps 6 – 10 to measure the in-place density of compacted bituminous pavements using a nuclear density gauge in the direct transmission mode.
7	Make a hole 2 in. deeper than the transmission depth being used with the drive pin and guide plate. NOTE: The hole must be as close as possible to 90° from the plane surface.
8	Firmly seat the density gauge on the prepared area so it is in full contact with the surface.
9	♦ Adjust the probe to the desired transmission depth. ♦ Pull the gauge so the probe is in contact with the side of the hole nearest the detector tubes.
10	♦ Measure and record the readings that are required for each location for the particular type of gauge used. ♦ Proceed to Step 11.
11	Use one of the following methods to determine the in-place density. ♦ Divide the field counts by the standard counts. ♦ Use the appropriate calibration curves, if necessary. NOTE: Most models are now programmable to provide direct reading of the nuclear density or percent compaction.
12	Take cores or sections of the pavement from the same area selected for the nuclear tests when correlating the nuclear density to the actual density of the compacted material.
13	♦ Measure the bulk specific gravity (G_a) of the cores or samples taken from the selected area tested for density according to 'Part I, Part II,' or 'Part III' of this test method. ♦ Establish a correlation factor using a minimum of 7 core densities and 7 nuclear densities. ♦ Adjust the nuclear density readings using this correlation factor to correlate with the actual G_a determined through laboratory testing. *NOTE*: When testing thin lifts in the backscatter mode, the influence of underlying strata with varying densities may render this procedure impractical without special planning. Most manuals for the nuclear gauge describe the various methods to use with thin lifts.
14	♦ Make correlations as described in Step 12 and compare the correlated nuclear density to the

Determining In-Place Density of Compacted Bituminous Mixtures Using a Nuclear Density Gauge	
Step	**Action**
	Gr or Grc of the mixture when controlling in-place density with the nuclear gauge. ♦ Calculate the percent density or directly read from programmable models to determine air-void content.

Section 5

Part IV, Establishing Roller Patterns (Control Strip Method)

Use this procedure to establish roller patterns for bituminous pavement.

Apparatus

Use the following apparatus:

- ♦ nuclear density gauge
- ♦ electrical impedance (nonnuclear) measurement gauge (optional)
- ♦ portable reference standard
- ♦ calibration curves for the nuclear gauge
- ♦ scraper plate and drill rod guide
- ♦ drill rod and driver or hammer
- ♦ shovel, sieve, trowel, or straightedge and miscellaneous hand tools
- ♦ gauge logbook.

Procedure

Follow these steps to establish roller patterns using the control strip method.

Establishing Roller Patterns (Control Strip Method)

Step	Action
1	Refer to the gauge manufacturer's instructions for operating the density gauge. *NOTE*: Standardize the equipment at the start of each day's use as described in 'Part III' of this test method when using a nuclear density gauge.
2	♦ Establish a control strip approximately 90 m (300 ft.) long and at least 3.5 m (12 ft.) wide or the width of the paving machine. ♦ Select 3 test sites. ♦ Avoid areas near edges or overlap of successive passes of the rollers.
3	♦ Allow the roller to complete a minimum of 2 coverages of the entire control strip before checking the density. ♦ Perform density tests at the 3 test sites selected. ♦ Record the results. ♦ Mark each test site very carefully so that subsequent tests made are in the same position and location. ♦ Use a colored marker keel to outline the gauge before taking the readings. ♦ Take the tests as quickly as possible and release rollers to complete additional coverage to prevent cooling of unrolled areas.
4	♦ Repeat the density tests at the previously marked test sites. ♦ Continue this process of rolling and testing until there is no significant increase in density. ♦ Try several different combinations of equipment, and numbers of passes with each

Establishing Roller Patterns (Control Strip Method)	
Step	**Action**
	combination, to determine the most effective rolling pattern. *NOTE*: In-place density determined with roadway cores is the final measure of rolling pattern effectiveness.
5	♦ Construct another section, without interruption, using the roller patterns and number of coverages determined by the control strip after completion of the control strip tests. ♦ Take random density tests on this section to verify the results from the control strip. *NOTE*: It may be possible to reduce the required coverages based on these tests.
6	Make density tests for job control according to the Guide Schedule for Sampling and Testing or as often as necessary, when some changes in the compacted material indicate the need.

Notes

Visual observation of the surface being compacted is a very important part of this procedure. Cease rolling and get an evaluation of the roller pattern if obvious signs of distress develop, such as, cracking, shoving, etc. Structural failures, due to over compaction, will cause the density tests to indicate the need for more compaction. Observe closely and take particular care when using vibratory rollers since they are more likely to produce over compaction in the material.

Use the minimum test time allowed by the particular gauge when measuring density on hot material, since the gauge may display erratic results if it is overheated.

Exercise particular care to clean the bottom of the gauge after it is used on asphalt pavement.

Use the correlation procedures outlined in 'Part III,' Step 13 of this test method when using specified density and rolling patterns.

This procedure provides a general guide to establish roller patterns. Follow the manufacturer's instruction manual furnished with the particular density gauge for specific operation of that gauge. This is essential since several different models and different brands are in standard use by the department.

Nuclear gauges and the user of the nuclear gauges must meet all requirements of the department's radioactive material license, "Nuclear Gauge Operating Procedures," and the *Texas Rules for Control of Radiation*.

Section 6

Part V, Determining Mat Segregation Using a Density-Testing Gauge

Use this procedure to identify segregation in bituminous pavements after placement on the roadway using a density-testing gauge.

Apparatus

Use the following apparatus:

- ♦ nuclear density gauge
- ♦ thin lift density gauge (optional)
- ♦ electrical impedance (nonnuclear) measurement gauge (optional)
- ♦ measuring tape (optional).

Forms

'Segregation Density Profile Form'

Procedure

Follow these steps to determine the mat segregation using a nuclear density gauge.

Determining Mat Segregation Using a Density-Testing Gauge

Step	Action
1	Refer to the manufacturer's instructions for operating the density gauge. *NOTE*: It is not necessary to calibrate the gauge to the mix.
2	Profile a 50 ft. section of the bituminous pavement.
3	Perform this step to profile a location where the paver stopped. ♦ Identify the location where the paver stopped paving, such as sporadic mix delivery. ♦ Move approximately 10 ft. behind the location where the paver stopped paving and mark and record this location as the beginning of the profile section. ♦ Proceed to Step 6.
4	Perform this step when profiling a random location. ♦ Randomly select an area. Choose an area with visible segregation, if possible. ♦ Proceed to Step 6.
5	Perform this step when profiling an area with segregation of longitudinal streaking greater than the profile length. ♦ Profile the area at an angle in a diagonal direction. ♦ Start the profile with a transverse offset of 2 ft. from the center of the longitudinal streak. ♦ End profile with a transverse offset of 2 ft. on the opposite side of the longitudinal streak. ♦ Do not start or end a profile less than 1 ft. from the pavement edge. ♦ Proceed to Step 7.
6	♦ Determine the transverse offset 2 ft. or more from the pavement edge.

Determining Mat Segregation Using a Density-Testing Gauge

Step	Action
	♦ Take density readings in a longitudinal direction and do not vary from this line. ♦ Visually observe the mat and note the surface texture in the section and the location of any visible segregated areas. ♦ Take additional readings along the transverse offset in areas with visible segregation. ♦ Include any visually segregated areas in the profile.
7	After completion of the final rolling patterns, position the density gauge at the identified location. ♦ Use of a nuclear density gauge • Take three 1 min. readings (minimum time length, longer readings can be used) in backscatter mode when using a nuclear density gauge at each random sample location. • It is optional to use fine sand passing the No. 40 sieve size to fill any voids without elevating the gauge above the rest of the mat. ♦ Use of an electrical impedance gauge • Take 2 readings; it is not necessary to move the gauge between readings. ♦ Record the in-place density gauge readings.
8	♦ Average the readings before moving the density gauge. ♦ Compare each individual reading to the average. ♦ Discard any single readings that vary more than 1 1b./cu. ft. from the average. ♦ Take additional readings to replace the discarded readings until all the readings are within 1 lb./cu. ft. of the average.
9	♦ Move the density gauge approximately 5 ft. forward in the direction of the paving operation. ♦ Take an additional set of readings at any location with visible segregation in between the 5 ft. distance.
10	♦ Repeat Steps 7, 8, and 9. ♦ Complete a minimum of 10 sets of readings. NOTE: Use a nuclear density gauge to verify impedance gauge readings whenever readings from an impedance gauge may not be accurate.
11	Determine the average density from all locations.
12	Determine the difference between the highest and lowest average density.
13	Determine the difference between the average and lowest average density.
14	Record the data using the example of ‘Segregation Profile Form.’

Example Segregation Profile Form

TEXAS DEPARTMENT OF TRANSPORTATION

SEGREGATION PROFILE
TEX-207-F, PART V

Refresh Workbook

File Version: 07/07/03 16:48:50

SAMPLE ID:		SAMPLED DATE:	
TEST NUMBER:		LETTING DATE:	
STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	1993
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	NONE
MATERIAL:		MIX TYPE:	Type C
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:	Surface	STATION:		DIST. FROM CL:	

LOCATION	DENSITY READINGS			AVERAGE
	1	2	3	
0'	142.0	141.0	142.7	141.9
5'	139.2	138.2	138.7	138.7
10'	140.2	140.9	140.5	140.5
15'	141.2	141.7	142.3	141.7
20'	138.9	138.2	137.7	138.3
25'	137.2	137.5	136.9	137.2
30'	139.4	139.5	139.7	139.5
35'	137.3	137.5	137.6	137.5
40'	140.2	140.3	140.9	140.5
45'	142.3	141.9	141.2	141.8
50'	140.3	140.5	139.8	140.2

AVERAGE READING:	139.8
HIGH READING:	141.9
LOW READING:	137.2

MAX ALLOWABLE DENSITY RANGE	
HIGHEST TO LOWEST:	4.7
AVERAGE TO LOWEST:	2.6

Remarks:

Section 7

Part VI, Bulk Specific Gravity of Compacted Bituminous Mixtures Using the Vacuum Method

Use this procedure to determine the bulk specific gravity of compacted bituminous mixtures using the vacuum device. This procedure is applicable for permeable friction course (PFC), gap graded mixtures such as coarse matrix high binder (CMHB), stone matrix asphalt (SMA), Superpave, and any other mixtures that have more than 2.0% water absorption by volume.

Apparatus

Use the following apparatus:

- specialized vacuum sealing device
- balance, readable to 0.1 g and accurate to 0.5 g, equipped with suitable apparatus to permit weighing of the specimen while suspended in water
- water bath, for immersing the specimen in water while suspended from a scale, equipped with an overflow outlet for maintaining a constant water level.

Test Specimens

Test specimens may be laboratory-molded mixtures, pavement cores, or pavement slabs.

Avoid distorting, bending or cracking the specimens during and after removal from pavements or molds. Store the specimens in a cool place.

Specimens must be free of foreign materials such as seal coat, tack coat, soil, paper, or foil. Remove any of these materials when they are visually evident with a saw or by any other satisfactory means.

For roadway cores, the sample size and number of samples must conform to the requirements of "Tex-222-F, Sampling Bituminous Mixtures."

Materials

Use the supply of large (approximately 16 in. × 16 in.) and small (approximately 14 in. × 10 in.) specialized polymer bags provided by the manufacturer.

Procedures

- ♦ Vacuum Device Setup

Follow these steps to perform the vacuum device setup.

Vacuum Device Setup	
Step	**Action**
1	Set the vacuum timer. *NOTE*: The manufacturer calibrates the vacuum pump timer setting and exhaust at the factory to eliminate drift and variability due to the sealing process. The vacuum pump operates for approximately one minute. Contact the manufacturer for adjustments if the vacuum pump stops before this time has elapsed.
2	Set the sealing bar timer in accordance with the vacuum device manufacturer's recommendations. *NOTE*: Inspect the seal quality after the first sealing operation. Reduce the setting if the polymer bag stretches or burns. Increase the setting if the seal is not complete or the bag easily separates.

- ♦ Compacted Bituminous Mixtures

Follow these steps to perform the bulk specific gravity of compacted bituminous mixtures.

Bulk Specific Gravity of Compacted Bituminous Mixtures Using a Vacuum Device	
Step	**Action**
1	Perform the following when testing laboratory-molded mixtures, roadway cores, or slabs that contain an absorption greater or equal to 2.0%. ♦ Oven-dry the specimens that contain moisture at a maximum temperature of 60 ±3°C (140 ±5°F) to a constant weight. *NOTE:* Constant weight is defined as the weight at which further drying does not alter the weight by more than 0.05% in a 2-hr. interval.
2	♦ Allow the specimen to cool to room temperature, and then weigh in air to the nearest 0.1 g. ♦ Record and designate this weight as 'A' under 'Calculations.' ♦ Proceed to Step 4.
3	Perform the following steps if testing laboratory-molded specimens or dry specimens. ♦ Allow laboratory-molded specimens or thoroughly dry specimens to cool to room temperature and then weigh the specimen in air to the nearest 0.1 g. ♦ Record and designate this weight as 'A' under 'Calculations.' ♦ Proceed to Step 4.
4	♦ Open the lid of the vacuum device. ♦ Stack or remove rectangular spacer plates in the vacuum chamber of the vacuum device so there is adequate space for the test specimen.
5	Place a sliding plate in the vacuum chamber on top of the spacer plates away from the seal bar. NOTE: Place the sliding plate in the chamber to reduce friction during the sealing operation.
6	Select a large or small polymer bag to use to seal the specimen. ♦ Use a large polymer bag for specimens with a diameter of 152.4 mm (6 in.) and a height or thickness greater than 50.8 mm (2 in.), i.e., Superpave gyratory molded specimens or field cores greater than 50.8 mm (2 in.) in thickness. ♦ Use a small polymer bag for specimens with a diameter of 101.6 mm and 152.4 mm (4 in. and 6 in.) and a height or thickness less than 50.8 mm (2 in.).

Bulk Specific Gravity of Compacted Bituminous Mixtures Using a Vacuum Device	
Step	**Action**
7	Weigh the selected polymer bag and record and designate this weight as ‘B’ under 'Calculations.'
8	Determine the polymer bag 'Correction Factor' (CF). ♦ Calculate the ratio, ‘R,’ by dividing the weight of the specimen by the weight of the bag. ♦ Use the Correction Factor Table provided in the manufacturer‘s operator guide. ♦ Look up the calculated ‘R’ value and record and designate the corresponding correction factor from the table as ‘CF.’
9	Perform Steps 9 - 16 to vacuum seal the specimens and to calculate G_a. ♦ Place the bag inside the chamber. ♦ Place the specimen in the polymer bag carefully avoiding punctures and tearing of the polymer bag. ♦ Center the core in the bag leaving approximately 25.4 mm (1 in.) of slack on the backside.
10	Position the bag so that approximately 25.4 mm (1 in.) of the open end of the bag is evenly against the sealing bar.
11	Close the lid of the vacuum device and hold firmly for 2 to 3 sec. NOTE: The vacuum pump will start and the lid will stay closed on its own. The vacuum gauge will read a vacuum less than 50 mm-Hg (28 in.-Hg).
12	♦ The lid of the vacuum device will automatically open upon completion of the sealing process. ♦ Carefully remove the sealed specimen from the chamber. ♦ Gently pull on the polymer bag to ensure the seal is tightly conformed to the specimen. ♦ Proceed to Step 7 if the seal is not tightly conformed to the specimen. NOTE: A loose seal may be an indication of a leak.
13	Determine the type of apparatus to use to weigh the samples suspended in water.
14	♦ Attach the apparatus to the scale and submerge in water. ♦ Tare the scale with the apparatus submerged in water.
15	♦ Completely submerge the sealed specimen in water at 25 ±2°C (77 ±3°F) and record the weight of the specimen in the bag. *NOTE*: Do not allow the polymer bag to touch the sides of the water bath. ♦ Weigh the sealed specimen in water. ♦ Record the weight to the nearest 0.1 g when the scale reading stabilizes. ♦ Designate this weight as ‘C’ under 'Calculations.'
16	♦ Remove the specimen from the polymer bag and reweigh the specimen in air. ♦ Compare this weight to the weight recorded for ‘A’ in Step 2 or 3. NOTE: A leak may have occurred if the difference in weight is greater than 5 g. ♦ Dry the sample to a constant weight at 60°C (140°F) and repeat the procedure with a new polymer bag if the difference in weight is greater than 5 g. *NOTE*: Constant weight is defined as the weight at which further drying at 60 ±3°C (140 ±5°F) does not alter the weight by more than 0.05% in a 2-hr. interval.
17	Do not use the test results calculated in this test procedure using the vacuum device if this method produces a bulk specific gravity that is higher than the bulk specific gravity calculated in ‘Part I’ of this test method. NOTE: Use the results calculated in ‘Part I’ of this method in this case.

Calculations

Calculate the bulk specific gravity of the compacted specimen using the following formula:

$$G_a = \frac{A}{\left[\left(A+B\right)-C\right]-\frac{B}{CF}}$$

Where:

- G_a = bulk specific gravity
- A = weight of specimen in air
- B = weight (grams) of the polymer bag in air
- C = weight (grams) of sealed specimen in water
- CF = correction factor.

Section 8

Part VII, Determining Longitudinal Joint Density Using a Density-Testing Gauge

Use this procedure to perform a longitudinal joint density evaluation on bituminous pavement using a density-testing gauge.

Apparatus

Use the following apparatus:

- ♦ nuclear density gauge
- ♦ thin lift density gauge (optional)
- ♦ electrical impedance (nonnuclear) measurement gauge (optional)
- ♦ measuring tape (optional).

Forms

'Longitudinal Joint Density Profile Form.'

Procedures

- ♦ Longitudinal Joint Density

Follow these steps to perform a longitudinal joint density evaluation on bituminous pavement.

Performing a Longitudinal Joint Density Using a Density-Testing Gauge

Step	Action
1	Refer to the manufacturer's instructions for operating the density gauge.
2	♦ Identify the random sample location selected for in-place air void testing. ♦ Mark and record this location as the reference point to perform the joint evaluation. NOTE: This point must be more than 2 ft. from the pavement edge.
3	Position the gauge at the random sample location selected for in-place air void testing identified in Step 2 after completion of the final rolling pattern.
4	♦ Use of a nuclear density gauge: • Take three 1 min. readings (minimum time length, longer readings can be used) in backscatter mode when using a nuclear density gauge. • It is optional to use fine sand passing the No. 40 sieve size to fill any voids without elevating the gauge above the rest of the mat. ♦ Use of an electrical impedance gauge: • Take 2 readings; it is not necessary to move the gauge between readings.
5	Record the density measurements from the density gauge at the random sample location selected for in-place air void testing.
6	♦ Measure the longitudinal joint density at the right and left edge of the mat, which is or will become a longitudinal joint.

Performing a Longitudinal Joint Density Using a Density-Testing Gauge	
Step	**Action**
	NOTE: Select a location that is perpendicular to the random sample location selected for in-place air void testing. ♦ Identify the joint type as 'Confined' or 'Unconfined.' NOTE: Take additional readings along the longitudinal joint at areas with visible irregularities or segregation.
7	♦ Position the gauge with the center of the gauge placed 8 in. from the pavement edge that is or will become a longitudinal joint. ♦ Orient the gauge so the longer dimension of the gauge is parallel to the longitudinal joint.
8	♦ Use of a nuclear density gauge: • Take three 1 min. readings (minimum time length, longer readings can be used) in backscatter mode when using a nuclear density gauge. • It is optional to use fine sand passing the No. 40 sieve size to fill any voids without elevating the gauge above the rest of the mat. ♦ Use of an electrical impedance gauge: • Take 2 readings; it is not necessary to move the gauge between readings.
9	Record the density measurements from the density gauge at the longitudinal joint.
10	Determine the difference in density between the readings taken at the random sample location selected for in-place air void testing and the readings taken at the longitudinal joint. NOTE: Use a nuclear density gauge to verify impedance gauge readings whenever readings from an impedance gauge may not be accurate.
11	Record and report the data using the example of the 'Longitudinal Joint Density Worksheet.'

♦ Joint Density Readings

Follow these steps to determine a correlated joint density.

Correlating the Joint Density	
Step	**Action**
1	Measure the bulk specific gravity (Ga) of the cores taken from each random sample location selected for in-place air void testing according to Part I, II, or VI of this test method.
2	Record the rice specific gravity (Gr) for each sublot evaluated for joint density.
3	Convert the sublot Ga and Gr to pounds per cubic foot by multiplying by the density of water 62.4 lb./cu. ft.
4	Determine the density gauge correlation factor. ♦ Record the average density gauge reading at the interior mat random sample location for in-place air voids (a). ♦ Record the average G_a in lb./cu. ft. (kg/m^3) of the cores taken at the random sample location for in-place air voids (b). ♦ Subtract the average density gauge reading (a) from the average G_a in lb./cu. ft.(kg/m^3) of the cores (b).
5	Add this value to the density gauge readings at each location evaluated for joint density.
6	Record and report the data using the example of the "Longitudinal Joint Density Worksheet."

Report Format

Use the following Excel programs to calculate and report density test results.

- QC/QA (used in conjunction with hot mix specification) test data worksheets (Tx2QCQA (for 1993/1995 Specifications) or Tx2QCQA04 [for 2004 Specifications]). (Refer to the 'Help' tab for detailed instructions on how to use the program.)
- 'Segregation Density Profile Form'
- 'Longitudinal Joint Density Profile Form.'

Example Longitudinal Joint Density Worksheet

TEXAS DEPARTMENT OF TRANSPORTATION

TEX-207-F, PART VII LONGITUDINAL JOINT DENSITY

Refresh Workbook

File Version: 03/24/04 15:23:40

SAMPLE ID:		SAMPLED DATE:	
TEST NUMBER:		LETTING DATE:	
STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	1993
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	NONE
MATERIAL:		MIX TYPE:	Type C
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:	Surface	STATION:		DIST. FROM CL:	

Type of Density Gauge:	Nuclear

Lot #	Sublot #	Station/ID Number	Travel Lane
1	1	156-A	NB
	2	156-B	NB
	3	156-C	NB
	4	156-D	NB

LEFT LONGITUDINAL JOINT

Type of Longitudinal Joint:	**Confined**

LEFT MAT EDGE LONGITUDINAL JOINT DENSITY					Density Difference Interior & Left Mat Edge	**INTERIOR MAT DENSITY**			
Sublot #	Gauge Readings (lbs/cf)			Average		Gauge Readings (lbs/cf)			Average
	1	2	3			1	2	3	
1	141.9	142.9	142.4	142.4	2.0	140.1	140.2	140.8	140.4
2	133.0	133.1	133.7	133.3	**12.0**	145.4	145.6	145.0	145.3
3	141.0	140.0	140.4	140.5	2.9	143.5	143.0	143.8	143.4
4	131.2	131.5	132.1	131.6	**5.9**	138.0	137.5	137.0	137.5

RIGHT LONGITUDINAL JOINT

Type of Longitudinal Joint:	**Confined**

RIGHT MAT EDGE LONGITUDINAL JOINT DENSITY					Density Difference Interior & Right Mat Edge	**INTERIOR MAT DENSITY**			
Sublot #	Gauge Readings (lbs/cf)			Average		Gauge Readings (lbs/cf)			Average
	1	2	3			1	2	3	
1	143.0	143.2	142.9	143.0	2.6	140.1	140.2	140.8	140.4
2	136.0	136.4	136.7	136.4	**8.9**	145.4	145.6	145.0	145.3
3	141.0	140.7	140.4	140.7	2.7	143.5	143.0	143.8	143.4
4	134.0	133.4	133.9	133.8	**3.7**	138.0	137.5	137.0	137.5

CORRELATED JOINT DENSITY, %

Rice Specific Gravity:	2.426

Sublot #	Interior Mat Density Roadway Core Bulk Specific Gravity			Correlated Joint Density	
	Core # 1 Ga	Core # 2 Ga	Average Ga	Left Mat Edge	Right Mat Edge
1	2.231	2.235	2.233	93.3	93.7
2	2.224	2.210	2.217	***83.4***	***85.5***
3	2.230	2.231	2.231	90.0	90.2
4	2.225	2.230	2.228	***87.9***	***89.4***

Other Related Calculations

Calculate the theoretical maximum specific gravity of the specimen for mixture design density calculations:

$$G_t = \frac{100}{\frac{A_g}{G_e} + \frac{A_s}{G_s}}$$

Where:

- ♦ G_t = calculated theoretical maximum specific gravity of the mixture at the asphalt content A_s. The G_t is required during the mix design phase to calculate the percent density or compaction for each asphalt content. Use this value to verify the results of the rice gravity laboratory test and ensure the correct percentages of asphalt and aggregates are in the mixture.
- ♦ A_g = percent by weight of aggregate in the mixture
- ♦ A_s = percent by weight of asphalt binder in the mixture
- ♦ G_e = effective specific gravity of the combined aggregate (see 'Part I, Typical Example of Design by Weight' of "Tex-204-F, Design of Bituminous Mixtures" for the formula)
- ♦ G_s = specific gravity of the asphalt binder determined at 25°C (77°F).

Calculate the percent density or percent compaction of the specimen:

$$Percent\ Density = \frac{G_a}{G_t\ \ or\ \ G_r\ \ or\ \ G_{rc}} \times 100$$

Where:

- ♦ G_a = actual bulk specific gravity of specimen
- ♦ G_t = theoretical maximum specific gravity of specimen
- ♦ G_r = theoretical maximum specific gravity ("Tex-227-F, Theoretical Maximum Specific Gravity of Bituminous Mixtures")
- ♦ G_{rc} = theoretical maximum specific gravity, corrected ("Tex-227-F, Theoretical Maximum Specific Gravity of Bituminous Mixtures").

Calculate the percent air voids in a compacted specimen:

$$Percent\ Air\ Voids = \left(1 - \frac{G_a}{G_r\ \ or\ \ G_{rc}}\right) \times 100$$

Where:

- ♦ G_a = actual bulk specific gravity of specimen
- ♦ G_r = theoretical maximum specific gravity ("Tex-227-F, Theoretical Maximum Specific Gravity of Bituminous Mixtures")
- ♦ G_{rc} = theoretical maximum specific gravity, corrected ("Tex-227-F, Theoretical Maximum Specific Gravity of Bituminous Mixtures").

Calculate the theoretical specific gravity (G_t) on the residual asphalt content of the cured mixture when designing mixtures under cold-mix asphaltic concrete specifications. In this case, the average bulk specific gravity of the combined aggregate (see "Tex-201-F, Bulk Specific Gravity and Water Absorption of Aggregate") may be used in lieu of G_e.

For example, assume a mixture containing 6% RC-2 cutback asphalt and 94% aggregate. Assume the test report for the RC-2 shows residual asphalt content to be 78.2% by weight.

- ♦ G = 2.652 average bulk specific gravity of aggregate
- ♦ G_s = 1.010 specific gravity of asphalt at 25°C (77°F) of residual bitumen from RC-2.

Then:

The 6% RC-2 will have 6.0 × 0.782 = 4.7% residual asphalt.

The total mixture of aggregate and residual asphalt will be equal to 94.0 + 4.7 or 98.7%.

Calculated on basis of 100% cured mixture:

$$A_g = \frac{94.0}{98.7} \times 100 = 95.2$$

$$A_s = \frac{4.7}{98.7} \times 100 = 4.8$$

$$95.2 + 4.8 = 100\%$$

The theoretical specific gravity of the cured mixture is equal to 2.460.

$$G_t = \frac{100}{\frac{95.2}{2.652} + \frac{4.8}{1.010}} = 2.460$$

Calculate the voids in the mineral aggregate (VMA) of compacted specimens:

$$VMA = 100 - \frac{G_a}{G_r \ or \ G_{rc}} \times (100) + \frac{G_a \times \% \ \text{AC}}{G_s}$$

Where:

- G_a = average actual bulk specific gravity of 3 specimens compacted according to "Tex-206-F, Compacting Specimens Using the Texas Gyratory Compactor (TGC)"
- G_r = theoretical maximum specific gravity ("Tex-227-F, Theoretical Maximum Specific Gravity of Bituminous Mixtures")
- G_{rc} = theoretical maximum specific gravity of specimen, corrected ("Tex-227-F Theoretical Maximum Specific Gravity of Bituminous Mixtures")
- % AC = asphalt content
- G_s = specific gravity of asphalt.

Section 9

Archived Versions

The following archived versions of "Tex-207-F, Determining Density of Compacted Bituminous Mixtures" are available:

- 207-0899 for the test procedure effective August 1999 through October 2004.
- 207-1104 for the test procedure effective November 2004 through December 2004.